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A New Genus and Species of Sardine from the Miocene Hishinai Formation, Northeastern Japan

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Abstract

A new upper Miocene sardine *Eosardinella hishinaiensis* new genus and species from the Hishinai formation, Northeastern Japan, is described in this paper. The new form closely resembles the recent Indo-Pacific species *Sardinella aurita* VALENCIENNES. *Clupea sardinites* HECKEL, a Polish Tertiary clupeid fish, may also belong to this new genus.

Introduction

In May 1961, the writer found and collected many fish fossil specimens from the the upper Miocene Hishinai formation distributed typically in the environs of Hishinai

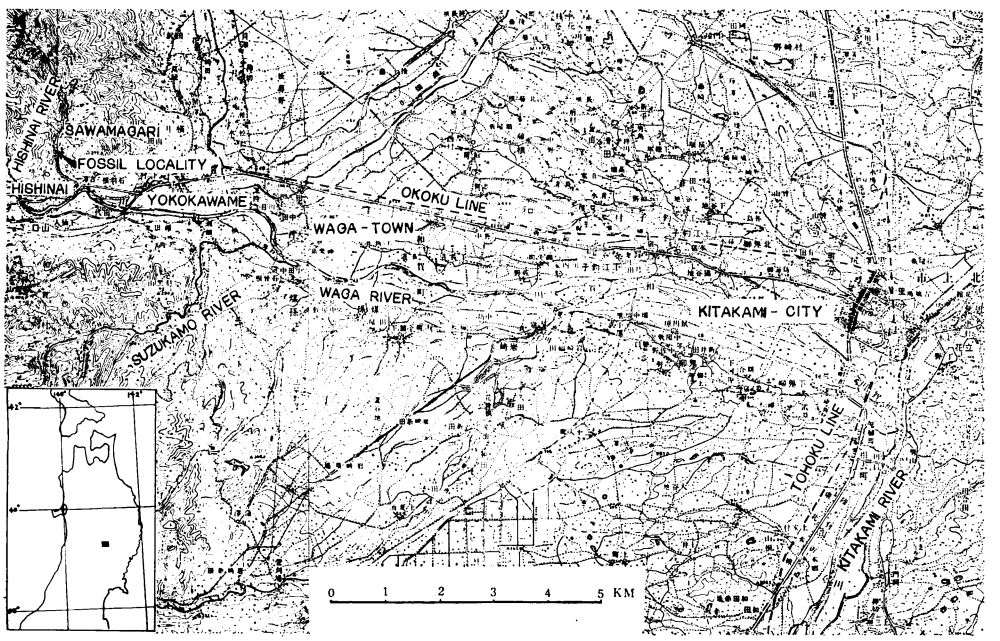


Fig. 1. Fossil Locality.

River, branch of Waga River, Iwate Prefecture, Northeastern Japan (Fig. 1). The morphological and osteological studies have revealed that the fossil specimens represent a new genus and species of the family Clupeidae. In this paper the writer gives a description of the new clupeid form together with a short geological note on the mode of occurrence and stratigraphical distribution of this species.

The writer takes this opportunity to express his hearty gratitude to Dr. Tokiharu ABE, Zoological Institute, Faculty of Science, University of Tokyo and Tokai Regional Fisheries Research Laboratory for instructive advice on ichthyological problems and reading the manuscript. His thanks are due to constant guidances on ichthyology of Prof. Kiyomatsu MATSUBARA, Drs. Akira OCHIAI and Tamotsu IWAI, Department of Fisheries, Faculty of Agriculture, Kyoto University. Acknowledgement is also due to Dr. Yukio KUWANO, Research Institute of Natural Resources, for his constant encouragement and paleontological advice.

The writer given knowledges on sardine by Mr. Keiichi KONDO, Tokai Regional Fisheries Research Laboratory and Prof. Zinjiro NAKAI, Tokai University. Mr. W. L. CHAN, Fisheries Research Station, Hong Kong, gave him some specimens of fishes of the genus Sardinella. The number of Research Group of the Backbone Range of Northeastern Japan, especially Prof. Mitsuo FUNAHASHI, Department of Geology and Mineralogy, Hokkaido University, Dr. Noboru YAMASHITA, Geological Institute, Faculty of Science, University of Tokyo, Dr. Yukinori FUJITA, Institute of Geology and Mineralogy, Tokyo University of Education, Drs. Atsuyuki MIZUNO, Toshihiro KAKIMI and Takashi MITSUNASHI, Geological Survey of Japan and Dr. Arata KUTSUZAWA, Mining college, Akita University, gave him instructive advices on stratigraphical problems. For those assistances, the writer expresses his sincere thanks to them.

Acknowledgements are also due to Prof. Shoji IJIRI, Economical college of Tokyo, Dr. Masae OMORI, Institute of Geology and Mineralogy, Tokyo University of Education and Prof. Michihei HOSHINO, Tokai University, for this constant guidances on paleontology and encouragements in various ways. Deep thanks of the writer is also due to Mr. Tokuo TAKAHASHI who was a teacher of Sennin Junior Secondary School, Waga-Town, Iwate Prefecture for the clue to the writer's detection of the fossil locality.

Geological Notes

(1) Stratigraphical note.

Stratigraphical survey of the Neogene system of this district were performed by some senior investigators since 1937 (MURAYAMA, 1937; KURATA, 1941; HAYAKAWA, FUNAYAMA, SAITO and KITAMURA, 1954; KITAMURA, 1959). But the result of detailed geological study was given by the Collaborate Research Group of the Backbone Range of Northeast Japan (MINATO, M. et al., 1965; FUJITA et al., 1966). The stratigraphical succession and correlation table based on data of the latter and the writer

Table 1. Correlation Table of the Neogene-System between the Area of Environs of Hishinai River and the Western Area of Shizukuishi-Basin.

Geological Age \ Area	Environs of Hishinai River (FUJITA et al. 1966)	Western Area of Shizukuishi-Basin (SATO, 1962)	
Pliocene Series	MOTOHATA FORMATION		
Miocene Series: Kitaura Stage		HASHIBA FORMATION	
Miocene Series: Funakawa Stage		ARASAWA FORMATION	OSUKE FORMATION
Miocene Series: Funakawa Stage	HISHINAI FORMATION	KOSHITOMAEZAWA FORMATION	OSUKE FORMATION
Miocene Series: Onnagawa Stage	TSUNATORI FORMATION	SAKAMOTOGAWA FORMATION	OSUKE FORMATION
Miocene Series: Nishikurosawa Stage	SUZUKAMOGAWA FORMATION	SAKAMOTOGAWA FORMATION	OSUKE FORMATION
Miocene Series: Nishikurosawa Stage	OISHI FORMATION	KUNIMITOGE FORMATION	
Miocene Series: Daijima Stage	OISHI FORMATION	KUNIMITOGE FORMATION	
Miocene Series: Nishioga Stage	OARASAWA FORMATION	OBONAI FORMATION	

is shown in Table 1 (SATO, 1962).

The fossiliferous beds belong to Hishinai formation typically developed in the valley of Hishinai River. Geological characteristics of the formation are as follows:

The distribution trends in the N-S direction along the eastern border of the backbone range. General strikes are N-S dipping monoclinally to the eastward, but in the type locality strikes have NE-SE or NEE-SEE, dipping to the southward. The thickness in the type locality is about 345 meters. Mainly composed of alternations of dark grey tuffaceous siltstone, sandstone and tuffs, intercalated with the zones of intraformational disturbances (Fig. 2).

(2) Mode of occurrence.

The fossiliferous beds are tuffaceous siltstones intercalated in the lower part of the formation. In the valley of Hishinai River the fossiliferous siltstone is found from two horizons which vertically close with each other. However the fish scale fossils of this species are commonly contained in the various horizons.

The fossil skeletons are densely piled up, not with a regular trend in orientation. In the majority of specimens, the osteotissues are mostly dissolved away and replaced by the carbonaceous materials probably derived from its muscles. The state of preservation are not good because the fossil-bearing tuffaceous siltstones are very loose. The molluscan fossils such as *Portlandia* cf. *lischkei*, *Macoma calcarea* and *Periploma yokoyamai* etc. are scatteredly in the beds together with the fish fossils (OTUKA 1941; FUJITA et al., 1966).

Other kinds of fish fossil collected from the same formation are only two specimens belonging to Scombridae and to Blenniidae, and the horizons of these are vertically distant from the horizons of the present new form.

(3) Stratigraphical distribution.

The writer had been also to know immediately during the present study that the identical specimens of this new species were widely distributed in the Miocene

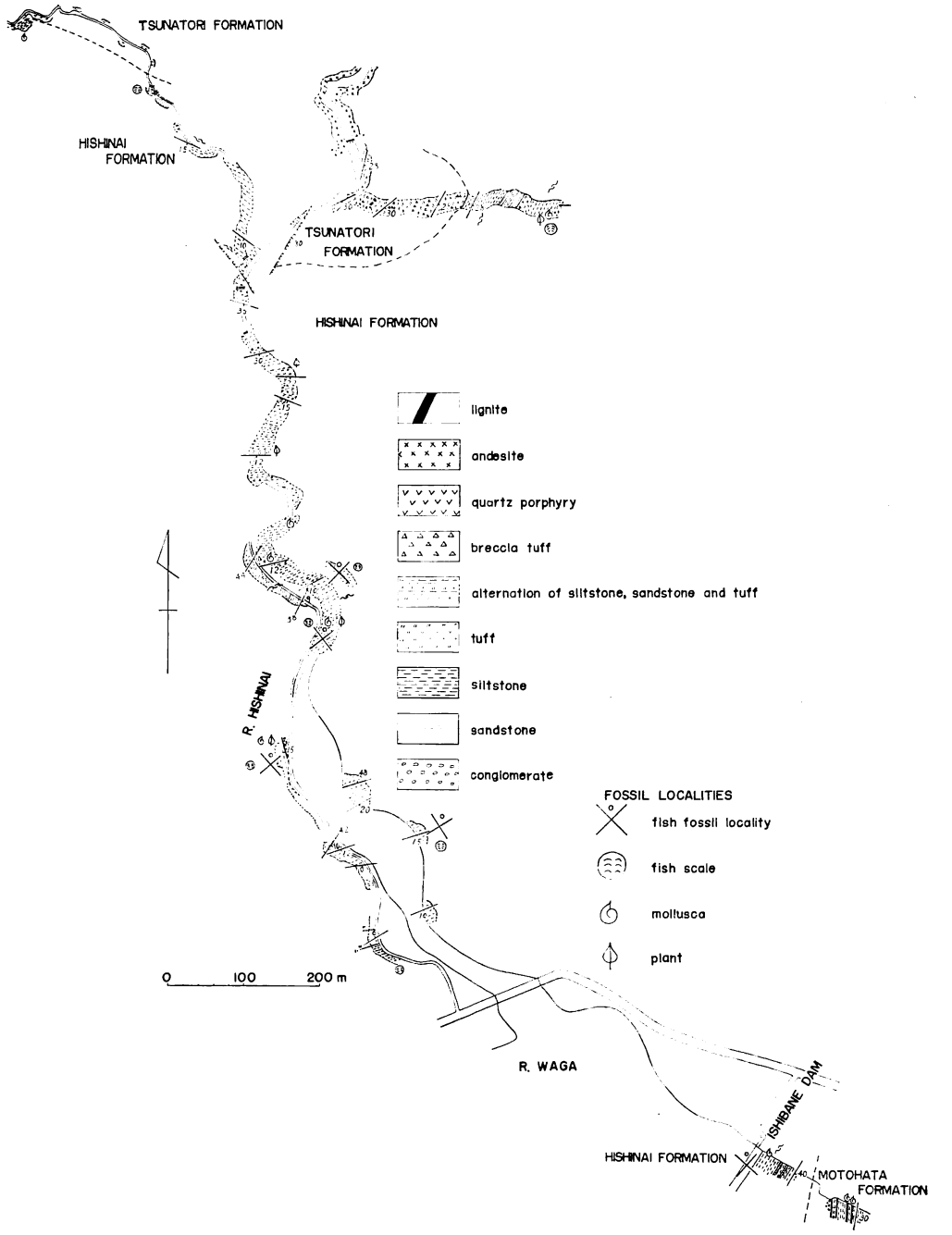


Fig. 2. Geological Route Map of the River Hishinai and its Environs.

formations of Northeastern Japan (OTSUKA, 1941; IJIRI, 1956); western area of Shizukuishi-basin in Iwate Prefecture (Sakamotogawa and Koshitomaezawa formations), Akita oil-field (Onnagawa formation) Niigata oil-field (Yuzawa formation, Nanatani formation etc.), Sado island (Nakayama formation), Northern Fossa Magna (Bessyo formation), Itsukaichi-basin in Kanto region (Itukaiti formation) and environs of Sendai City (Nanakita formation) (Fig. 3) (Geol. Soc. Jap., 1952-1962). Namely, it may be possible to say that the present fish was a representative in some layer of the Miocene paleo-sea around the Japanese islands.

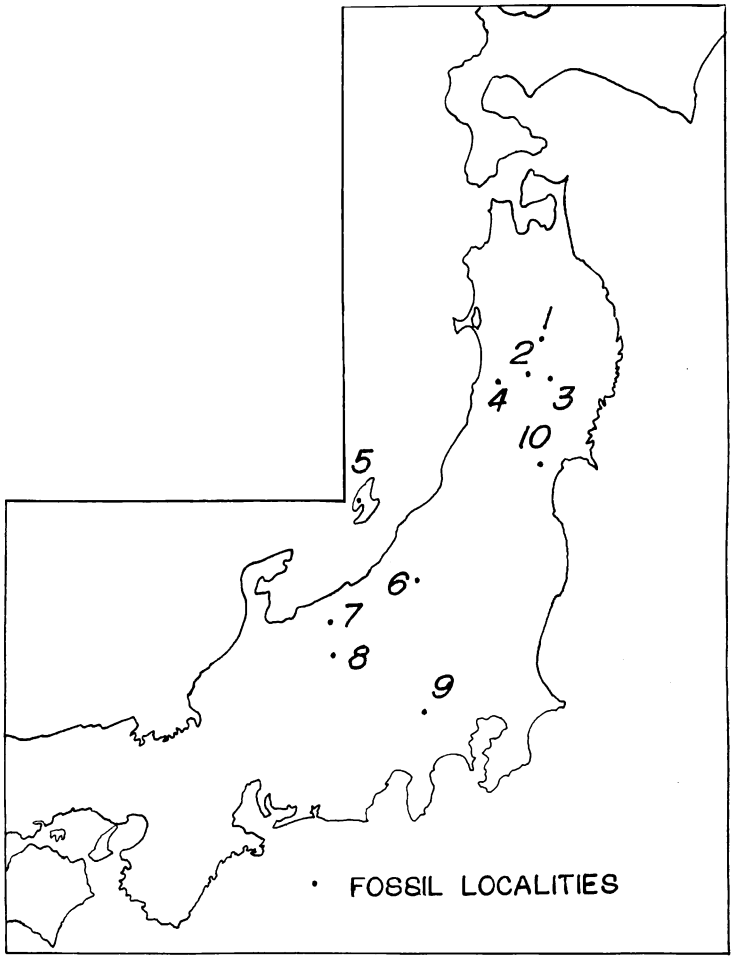


Fig. 3. Stratigraphical Distribution of *Eosardinella hishinaiensis*, n. gen. and sp. (1. Shizukuishi Basin, 2. Hiraga Basin, 3. Hishinai River, 4. Akita Oil-Field, 5. Sado Island, 6, 7. Niigata Oil-Field, 8. Northern Fossa Magna, 9. Itsukaichi Basin, 10. Environs of Sendai-City.

Table 2. Dimensions of Holotype and Paratype Specimens of *Eosardinella hishinaiensis*, New Genus and Species.

Dimensions / Cat. Nos. of Specimens		Standard length (mm)	Head length (mm)	Depth (mm)	Snout —Dorsal insertion (mm)	Snout —Ventral inseation (mm)	Snout —Anal insertion (mm)	Snout (mm)	Orbital fossa (mm)	Dorsal fin base (mm)	Anal fin base (mm)
Holotype :	913	152.0	38.0	38.0	ca. 70.0	76.5	(?)128.0	ca. 12.0	10.0	(?) 8.5+	(?)13.0+
	903	153.0	(?)34.0	38.0	69.0	74.0	(?)127.0		11.0		
	907	157.0	38.0	ca. 36.0	69.0	89.0	131.0			22.0	19.0
	908		38.0	ca. 38.0	71.5				(?)14.0+	(?)14.0+	
	912	161.0	38.0	(?)34.0+	(?)75.0			13.0	10.5		
	914	151.5	39.0	(?)32.0	67.0	(?)84.0+			10.0	(?) 7.5+	
Paratypes :	917		37.0	39.0	74.0	88.0					
	924							14.0			19.0
	927		40.0	ca. 38.0	72.0			13.0	10.0	(?)16.0+	
	928		41.0	ca. 38.0				13.0	11.0		
	928			ca. 26.0						(?)17.0+	15.0
	930		42.5							(?)11.0+	

Description

Family Clupeidae

Subfamily Clupeinae

Genus *Eosardinella*, new genus

Typse species; *Eosardinella hishinaiensis*, new species.

Diagnosis.—Body elongate and compressed. Belly bears well-developed ventral scutes. Dorsal fin base median of body. Ventral fin base is behind the commencement of dorsal fin. Anal fin base reaches near caudal fin base. Caudal fin homocercal and forked.

Head rather short, as long as the depth of body. Eye moderately large. Mouth terminal and its cleft small. Upper jaw bordered by premaxillary and maxillary, the latter bearing two supramaxillaries. Lower jaw high, the articulation between lower jaw and skull not farther than the perpendicular through anterior border of eye. Vomer, premaxillary, maxillary and dentary toothless. Operculum bears a pair of parallel ridges along its anterior border.

Scale cycloid and deciduous, subpentagonally or longish subhexangular in shape. Focus absent. Several well-bended transverse grooves develop symmetrically in upper and lateral areas.

Profile of cranium right-angled triangular, and occipital region rather high. Sphenotic triangular in shape protruding excessively laterally.

Table 3. Comparison of Counts of Fin Rays and Vertebrae between *Eosardinella hishinaiensis*, *Sardinella aurita* and *Clupea tiejei*.

Specimens		Dorsal ray	Pectoral ray	Pelvic ray	Anal ray	Vertebrae
Holotype:	913	8+(?)	4+(?)	4+(?)	7+(?)	ca. 47(33 or 34)+14
Paratypes:	903		8+(?)		ca. 15+(?)	
	907	ca. 18	11+(?)	6+(?)	ca. 15+(?)	(?)+14
	912		6+(?)			47(33+14)
	914	10+(?)	12+(?)	2+(?)	4+(?)	ca. 47
	917		9+(?)	3+(?)		
	924				ca. 18	
	927	11+(?)	12+(?)			
	928		11+(?)			
	929	16+(?)	ca. 15		ca. 16+(?)	
	930	15+(?)				
Clupea tiejei DAVID		19 or 20	14	(?)	17	47
Sardinella aurita VALENCIENNES		14-16 19(17-20)	13-15 15(14-16)	9 9	13-15 17(15-18)	46-49 —

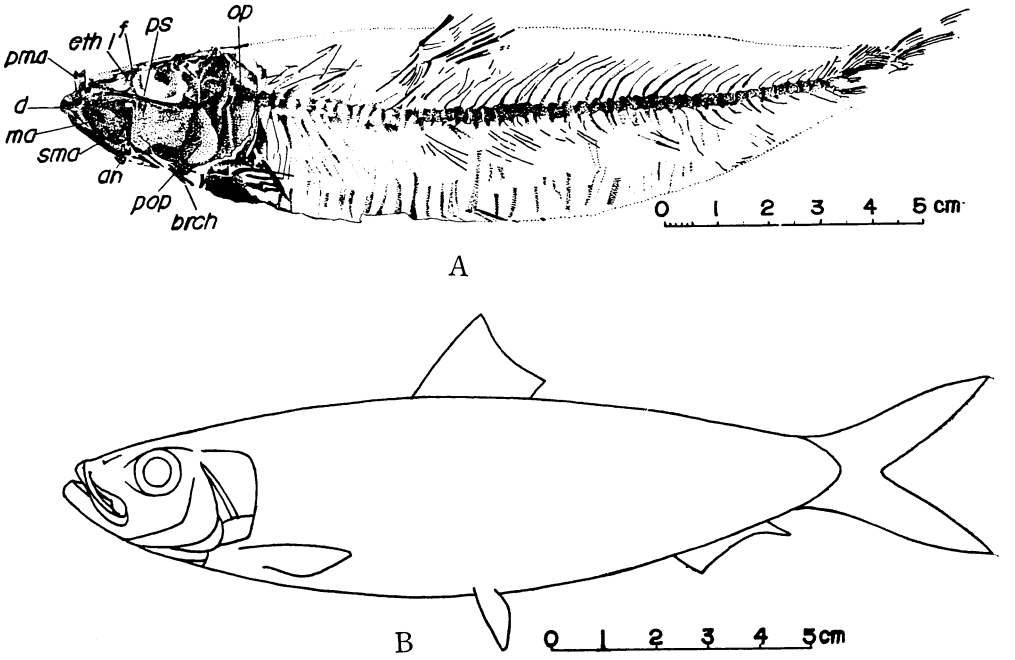
This new genus is allied to genus *Sardinella* VALENCIENNES in general form of both body and skull, but differs from the latter at least in having a pair of parallel very-pronounced ridges along the anterior border of operculum, and in having longish subhexangular scales bearing well-bended transverse grooves (CUVIER et VALENCIENNES, 1847; REGAN, 1917; FOWLER, 1941; PHILLIPS, 1942; CHAPMAN, 1944; SVETOVIDOV, 1952; MATSUBARA, 1955; NIKOL'SKII, 1961; CHAN, 1965).

JERZMANSKA'S Polish Tertiary sardine, *Clupea sardinites* HECKEL, may be included in this new genus because it bears a pair of parallel ridges in the anterior border of opeculum (WOODWARD, 1901; JERZMANSKA, 1960).

Eosardinella hishinaiensis, new species

(Figs. 4-8, pls. 1-3)

Study materials: Holotype. Cat. No. 913, Department of Engineering Geology, Kurosawajiri Technical High School. Standard length 152 mm. Taken by the writer in the Hishinai formation (upper Miocene), 39°18′36″N. L., Long. 140°56′52″E., Hishinai River, Waga-Town, Iwate Pref., Japan, 1961. Paratypes. Cat. Nos. 903, 907, 912, 914, 917, 924, 927-930, Department of Engineering Geology, Kurosawajiri Technical High School. Standard length 151.1 mm.-161.0 mm. and fragments of bodies. Taken by



Figs. 4. A. Holotype of *Eosardinella hishinaiensis*, new genus and species, B. Reconstruction Figure of *Eosardinella hishinaiensis*, new genus and species. an. angular, brch. branchial, d. dentary, ethl. ethmoid lateral, f. frontal, ma. maxillary, op. operculum, pma. premaxillary, pop. preoperculum, ps. parasphenoid, sma. supramaxillary.

the writer in the Hishinai formation, 1961.

Counts of fin rays*. D. 8+? (10+?-ca. 18); P. 4+? (6+?-ca. 15); V. 4+? (2+?-6+?); A. invisible (4+?-ca. 18).

Proportional dimensions in present of standard length*.

Length of head 25.0 (22.3-25.7).

Greatest depth of body 25.0 (21.1-24.8).

Distance from tip of snout to dorsal origin ca. 46.1 (43.9-45.1).

Distance from tip of snout to pelvic origin 50.3 (48.3-56.7).

Distance from tip of snout to anal origin 84.2 (83.0-83.4).

Proportional dimensions in percent of head length*.

Length of snout ca. 31.5 (31.7-34.2).

Diameter of orbital fossa 26.3 (25.0-36.8).

Length of dorsal fin base 22.3+? (36.8+?-57.8).

Length of anal fin base 34.2+? (50.0).

General appearance.—Body elongate and compressed anteriorly and posteriorly, upper and lower profiles very gently curved in subsimilar form. Deepest at commencement of dorsal fin base. Belly bears well-developed ventral scutes.

Head rather short, as long as the depth of body. Snout bruntly pointed, the length somewhat longer than the diameter of eye. Eye moderately large. Upper jaw bordered by premaxillary, maxillary and supramaxillaries, obliquely subrounded backward and downward, extending a vertical line through anterior rim of orbital fossa. Cleft of mouth appears to be small and lower jaw more or less prominents when mouth is closed. Lower jaw rather high. Articulation between lower jaw and skull not farther the vertical line through anterior rim of orbital fossa. Operculum bears a pair of parallel very-pronounced ridges along its anterior border.

Pectoral fin base closes belly. Commencement of dorsal fin more or less nearer tip of snout than caudal fin base, distance from tip of snout to commencement of dorsal fin 1.7-2.0 times of head length. Ventral fin base is located underneath and behind the commencement of dorsal fin. Commencement of anal fin far behind a perpendicular line through posterior end of dorsal fin base, the terminal of the base appears to be very closes caudal fin base. Caudal fin homocercal and forked-shape.

Scales.—Scales cycloid, medium size, subpentagonally or longish subhexangular in general shapes and appear to be deciduous. Focus absent. The basal tip bruntly pointed, apex being broadly angulate. Several transverse grooves develop symmetrically in upper and lower lateral areas, and the grooves excessively bend forward at the point of distance of about 1/3-1/2 times from a line drawn between basal tip and apex. Well-developed very fine transverse ridges visible in basal and lateral areas.

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* Parenthesized proportional dimensions and counts refer to the paratypes.

Skeleton.—Profile of cranium right-angled triangular, occipital region rather high, postorbital length shorter than the diameter of orbital fossa and as long as the length of snout. Supraoccipital situates posterodorsal corner of cranium, the median ridge low and the anterior margin joins smoothly posterior area of frontal. Frontal seems to be rather flat. Two wings of lateral ethmoid protrudes laterally from underneath the anterolateral border of frontal. Mesethmoid joins anterior border of frontal, the posterior half of its dorsal margin appears to be somewhat depressed. Vomer bears closely underneath mesethmoid, the ventral surface and the anterior prolongation of

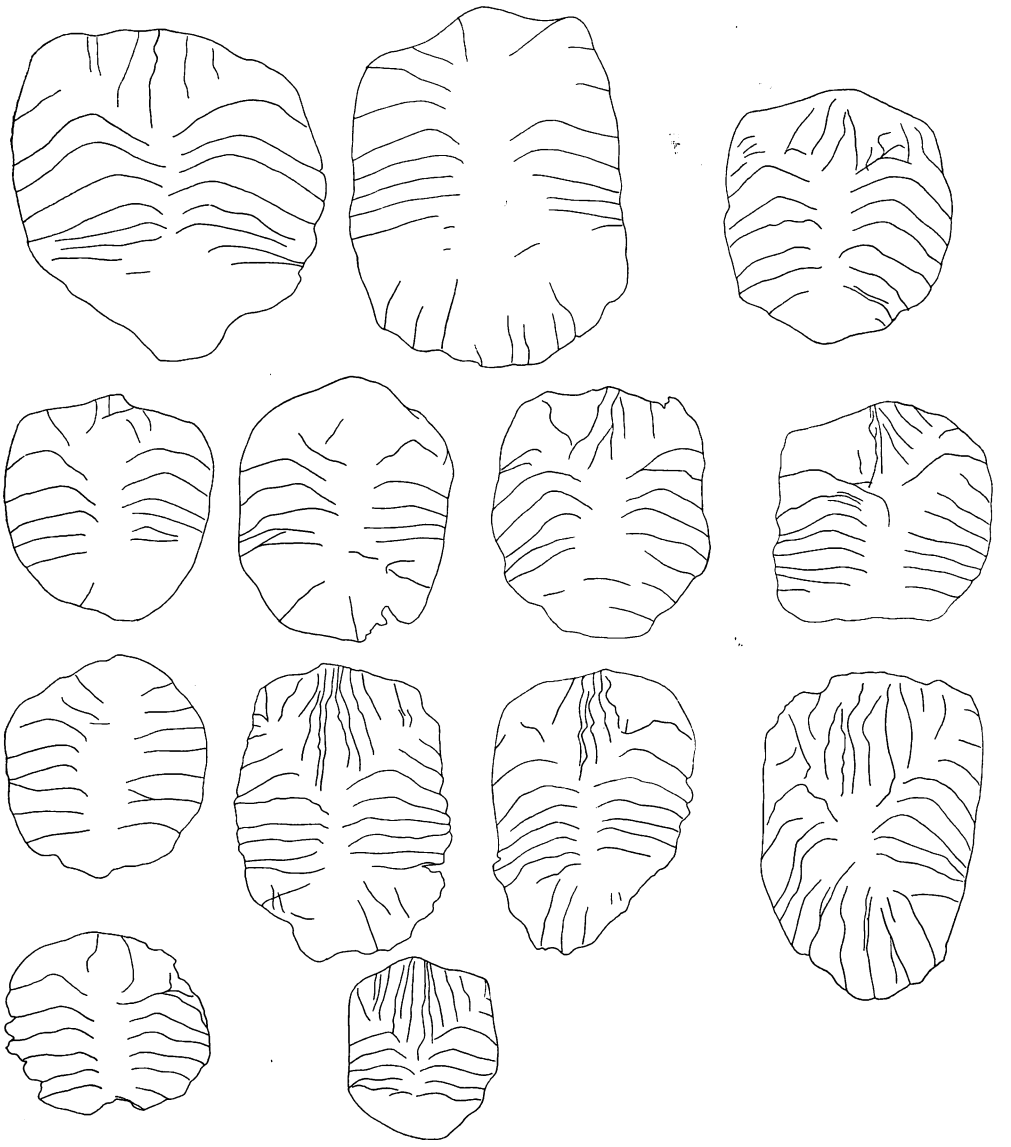
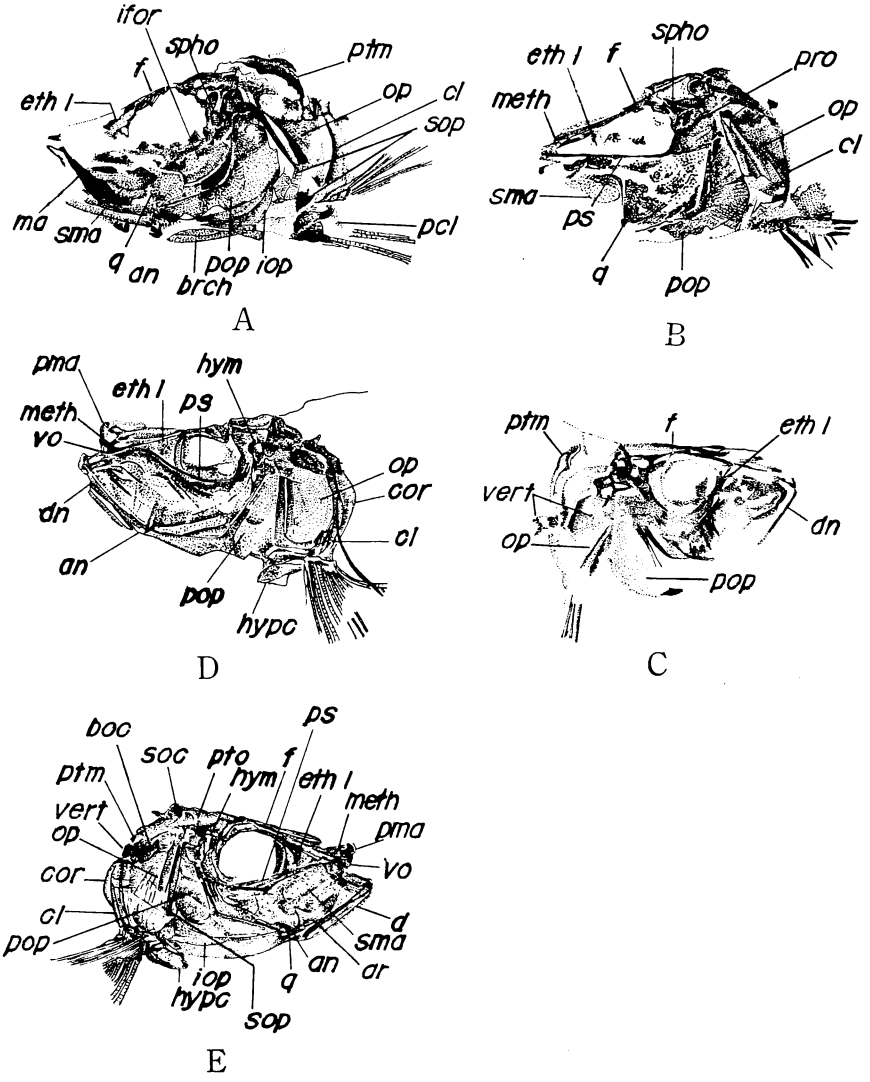


Fig. 5. Fish Scales of *Eosardinella hishinaiensis*, n. gen. and sp. (bearing parts are unknown).

parasphenoid an evenly curved line, transverse extensions develop at the tip. Pterotic appears to be rather flat and terminates in a long. Sphenotic joins lateral margin of pterotic, seems to be triangular in shape and excessively protrudes laterally.

Hyomandibular connects directly with relationship of a right-angle to ventral



Figs. 6. Head Regions of Paratypes of *Eosardinella hishinaiensis*, n. gen. and sp. A. Cat. no. 918, B. Cat. no. 916, C. Cat. no. 912, D. Cat. no. 928, E. Cat. no. 927.

ac. actinosts, an. angular, ar. articular, boc. basioccipital, brch. branchial, cl. clavicle, cor. coracoid, d., dn. dentary, ethl. ethmoid lateral, f. frontal, hypc. hypercoracoid, hym. hyomandibular, ifor. infraorbital, iop. interoperculum, ma. maxillary, meth. meseth-moid, op. operculum, pcl. post-clavicle, pma. premaxillary, pop. preoperculum, pro. pro-otic, ps. parasphenoid, ptm. post-temporal, pto. pterotic, q. quadrate, sma. supramaxil-lary, soc. supraoccipital, sop. supoperculum, spho. sphenotic, vert. vertebrae, vo. vomer.

surface of pterotic and sphenotic. Symplectic seems to be prolonged far beyond a vertical line through median of orbital fossa although the former invisible. Quadrate underneath anterior half of orbital fossa, triangular in shape. Dentary toothless, high and subtrapezoidal in its profile, the tip bruntly pointed and the posterior border is joined with articular. Angular small, connects closely to posterolower corner of dentary. Preoperculum crescent-shaped, the anterior border excessively arcuate and the posterior border broadly subrounded. Operculum more or less narrow, bears a pair of parallel very-pronounced ridges along its anterior border. Anterior area of interoperculum is covered with posterolower border of preoperculum. Suboperculum bears directly underneath the lower border of operculum, the posterolower border

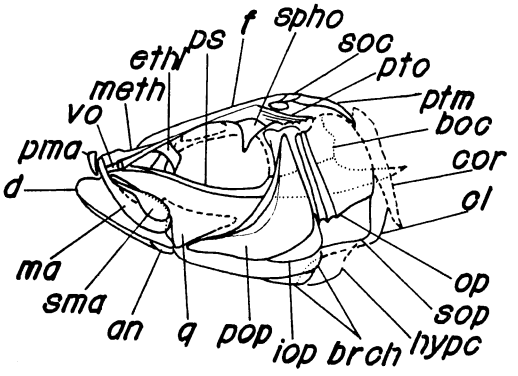


Fig. 7. Reconstruction Figure of Skull and Shoulder Regions of *Eosardinella hishinaiensis*, n. gen. and sp. (Abbreviations after Figs. 6)

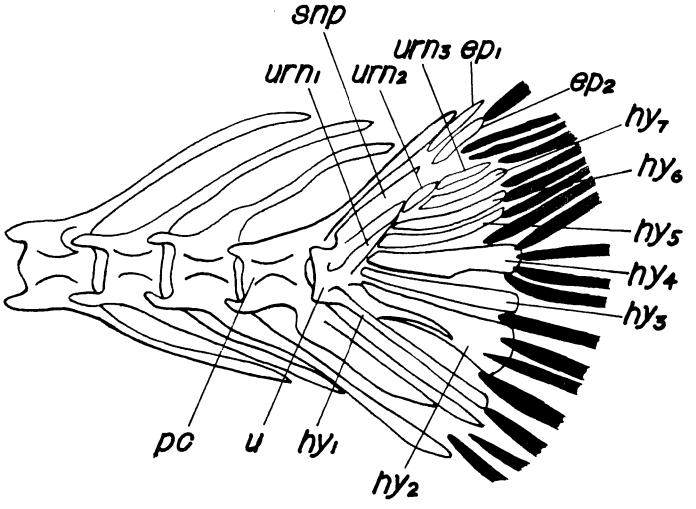


Fig. 8. Reconstruction Figure of Caudal Skeleton of *Eosardinella hishinaiensis*, n. gen. and sp. ep_1-ep_2, epural 1-2, hy_1-hy_7. hypural 1-7, pc. penultimate centrum, snp. specialized neural process, u. urostyle, urn_1-urn_3. uroneural 1-3.

angulate. Premaxillary small, bears tip of mesethmoid. Maxillary extends posteriorly, the tip bears anterolateral of mesethmoid and becomes wide posteriorly. Supramaxillaries appear to be two. Premaxillary, maxillary and vomer also toothless. Palatine branchials border ventral profile between terminal of dentary and posterior end of skull.

Post-temporal seems to bear to dorsal surface of epiotic and terminates in a long posterolaterally. Clavicle arcuates anteriorly. Hypacoracoid situates below suboperculum and posterolower region of interoperculum.

Vertebrae 33+14=47. Vertebral colum isospondylous. Haemal ribs, neural spines fine and feeble. Epineural, epipleural and epicentral well develop. Posterior end of hypurals straight in their outline. Three pairs of uroneurals, seven hypurals and two epurals are attached to urostyle. Neural spines of urostyle (specialized neural process) (HOLLISTER, 1936; HAYASHI, 1961) compressed and spindle in shape. The third hypural fuses firmly with urostyle. A short wing-like process seems to develop anteroventral border of the second hypural.

Relationships.—The present new species resembles *Sardinella aurita* VALENCIENNES, an Indo-Pacific form, in having the following characters; 1) occipital region is rather high, 2) hyomandibular bone connects directly with relationship of vertical to ventral surface of pterotic and sphenotic bones, and symplectic bone seems to be prolonged far beyond a vertical line through median of orbital fossa, 3) a pair of parallel very-pronounced ridges develop along the anterior margin of operculum (*Sardinella aurita* leaves a pair of rudimentary ridges along the anterior margin of operculum), 4) triangle-shaped sphenotic bone is protruded laterally. However this species undoubtedly distinguished from the former in having higher body and bolder ridges in operculum and in having longish subhexangular-shaped scale (CUVIER et VALENCINNES, 1847; KISHINOUYE, 1907; REGAN, 1917; FOWLER, 1941; PHILLIPS, 1942; SVETOVIDOV, 1952; CHAN, 1965).

The new species under report also resembles to *Clupea tiejei* DAVID, Californian Miocene clupeid fish (DAVID, 1943), in general physiognomy and proportions. But this new species differs from the former at least in having larger eye and a pair of parallel distinct ridges in operculum.

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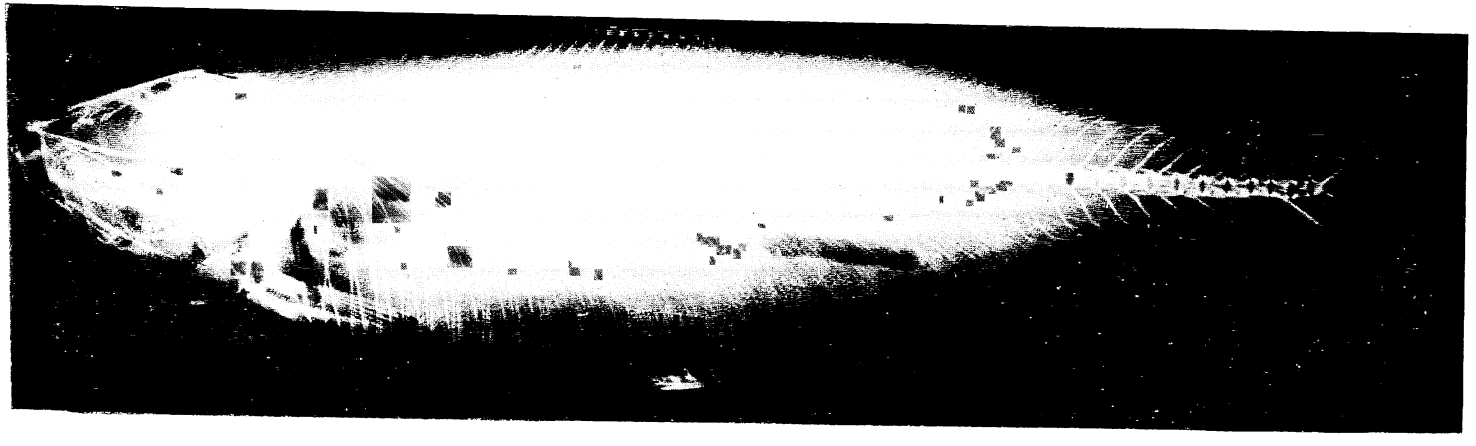
A

B



C

Plate 1. A. Holotype of *Eosardinella hishinaiensis*, n. gen. and sp. (×1).
B. Paratype (Cat. no. 929) of *Eosardinella hishinaiensis*, n. gen. and sp. ×ca. 1.4).
C. Soft X-Ray Photograph of *Sardinella aurita* VALENCIENNES. (×ca. 0.8).

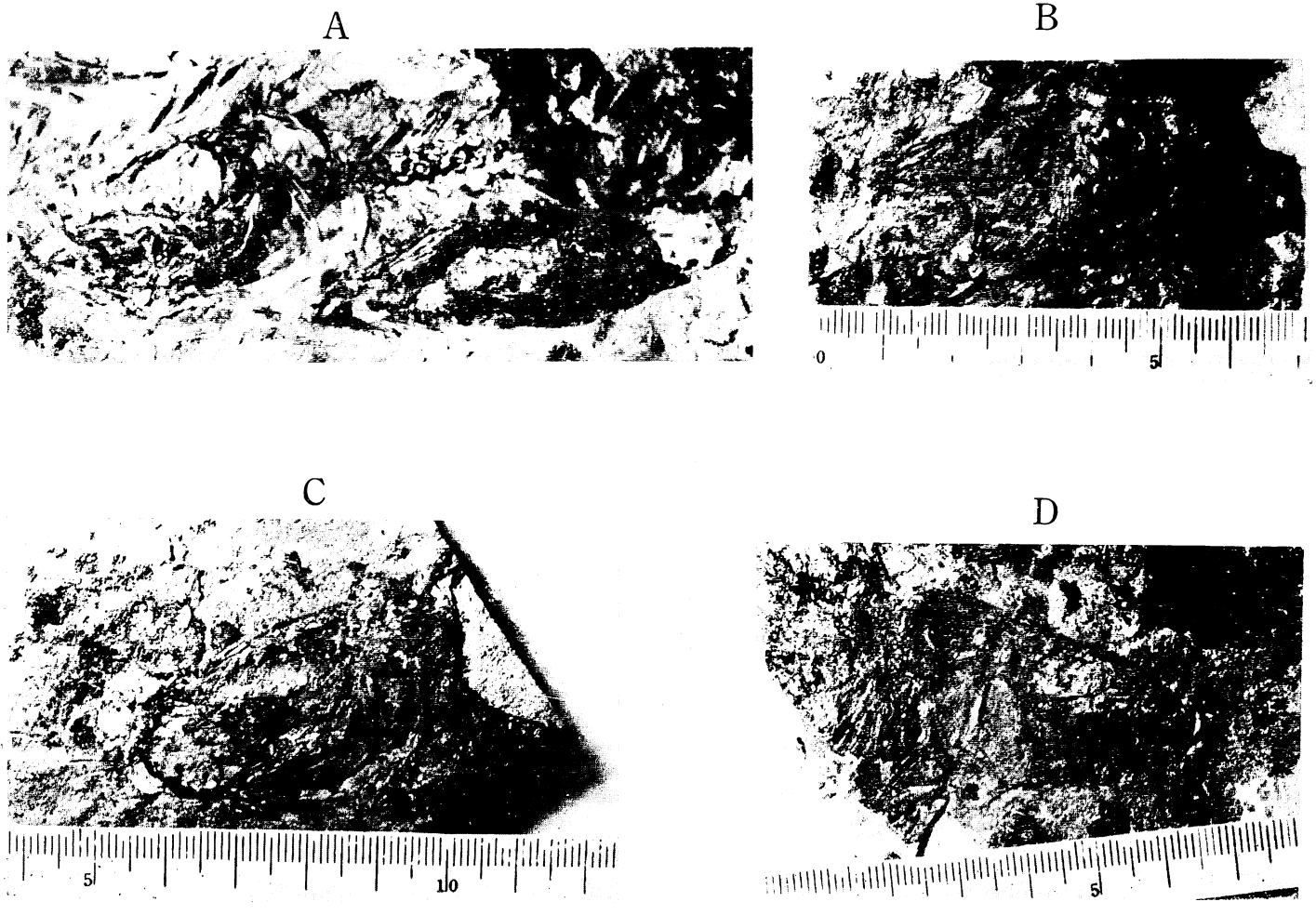


Plate 2. Paratype specimens of *Eosardinella hishinaiensis*, n. gen. and sp. (×1).
(A. Cat. no. 918, B. Cat. no. 916, C. Cat. no. 921, D. Cat. no. 908)

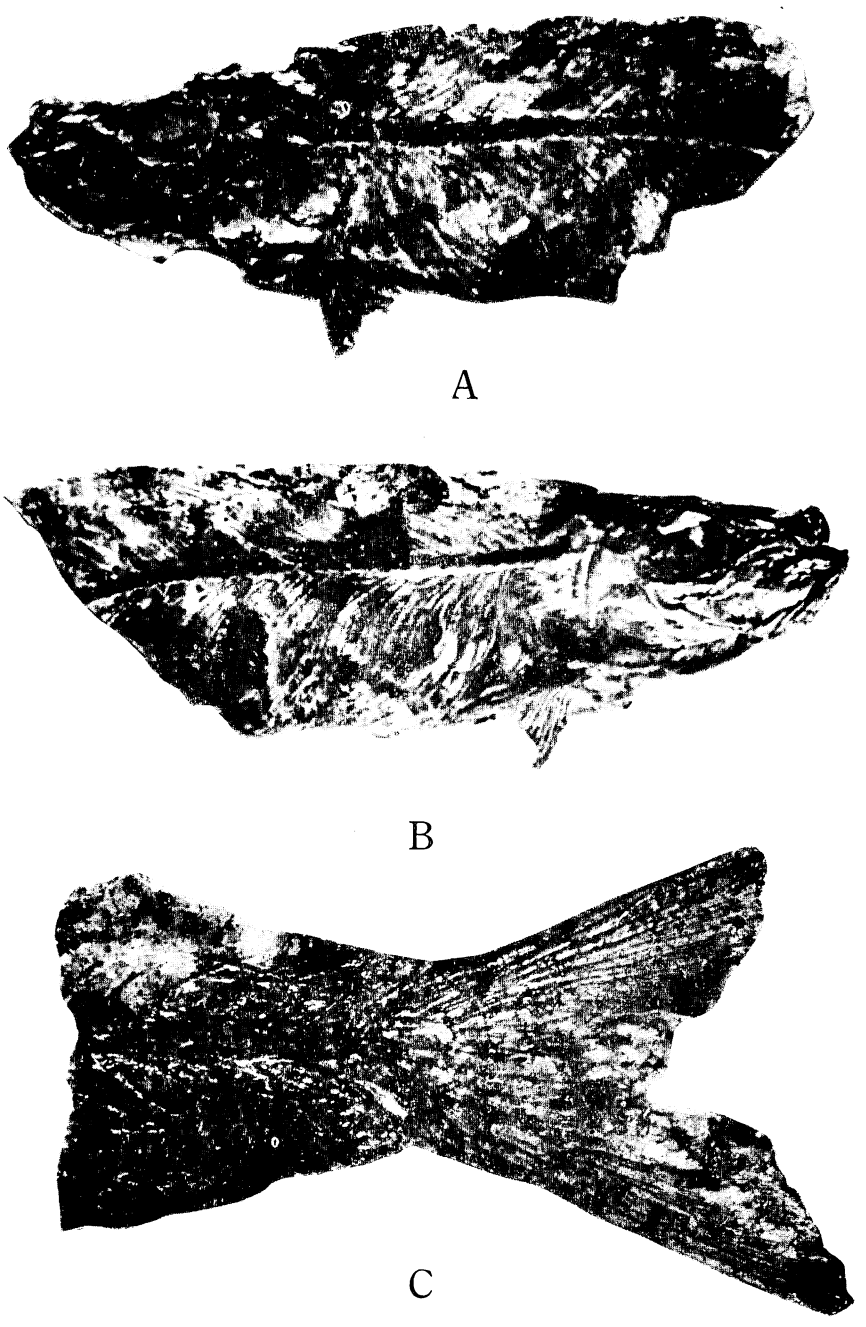


Plate 3. Paratype of *Eosardinella hishinaiensis*, n. gen. and sp.
(A. Cat. no. 928, ×1 ; B. Cat. no. 927, ×1 ; C. Cat. no. 900, ×ca. 2.5)